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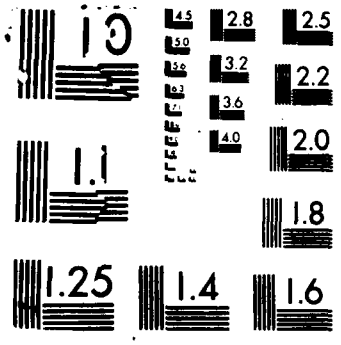
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ANNUAL REPORT

for

1 July 1986 through 30 June 1987

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Contract N00014-85-K-0489

MATRIX THEORY

Henryk Minc, Principal Investigator

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Santa Barbara, CA 93106

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June 22, 1987.

From: Henryk Minc, Principal Investigator,
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Santa Barbara, CA 93106.

To: Dr. F.R. McMorris
Scientific Officer
Mathematical Sciences Division
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Arlington, Virginia 22217-5000

Subj.: ONR Contract N00014-85-K-0489.
Annual Report, 1 July 1986 - 30 June 1987.

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Dear Dr. McMorris,

During the past year I worked in two areas of matrix theory: the theory of permanents, and the theory of nonnegative matrices. I enclose a list of my publications completed during the year.

Paper [1] deals with permanental compounds and their use in recurrence formulas for permanents of (0,1)-circulants and in related asymptotic formulas. I have already reported on this work in my annual report for 1985/1986. In August 1986 I presented the results obtained in [1] at the International Congress of Mathematicians in Berkeley. The paper has now appeared in print.

Paper [2] is an extensive survey of the progress in the theory of permanents achieved during the quadrennium 1982-1985. It is a sequel to my paper "Theory of Permanents 1978-1981" [*Linear and Multilinear Algebra* **18** (1983), 227-263], which in turn is a

sequel to my treatise "*Permanents*" [*Ency. of Math. and Its Appl.*, volume 6, Addison-Wesley, Reading, 1978]. The paper contains a general survey of new results in the theory of permanents and sections on special topics: (1) Friedland's proof of Tverberg's conjecture, (2) the minimum permanents in various classes of doubly stochastic matrices, and (3) the permanents of (0,1)-circulants, an area in which I have been working for several years. The paper also contains a list of unresolved conjectures and unsolved problems, and a report on their current status. The work concludes with a bibliography containing 116 titles, each listed with a short abstract.

Paper [3] deals with the problem of determining the minimum permanent in the set of $n \times n$ doubly stochastic matrices whose first k main diagonal entries are equal to zero. The case $k = 0$ is the famed van der Waerden conjecture. The case $k = 1$ can be easily solved by a method similar to that used by Egoryčev in proving the van der Waerden conjecture. For $k = 2$ Egoryčev's techniques are of limited use. This case was solved by me in 1984. For $3 \leq k \leq n$ the problem is still unsolved. Brualdi [*Linear and Multilinear Algebra* **17** (1985), 5-18] conjectured that for $k = n - 1$ the minimum is achieved uniquely for the matrix whose last row and last column entries are all equal to $n - 1$, and all its other off-diagonal entries are $(n-1)/n(n-2)$. In [3] I have shown that Brualdi's conjecture is false for all

$n \geq 5$. I have also determined the unique "minimizing" matrix on the assumption that the permanent function takes its minimum for a matrix whose off-diagonal entries outside its last row and last column are all equal (the assumption is tantamount to an affirmative answer to a problem proposed by Brualdi). The general problem is extremely difficult. It is unsolved even for $n = 4$. I plan to continue to study this problem.

The monograph *Nonnegative Matrices* [4] is an advanced book on which I have been working for several years. During the past year I have written the two concluding chapters of the work. The penultimate chapter, which extends to 49 typed pages, deals with stochastic matrices, totally nonnegative matrices, oscillatory matrices, and M-matrices. The last chapter (53 typed pages) contains sections on the inverse eigenvalue problem, the inverse spectrum problem, and the inverse elementary divisor problem for nonnegative matrices. The book is now completed; it will be published in 1988.

Yours sincerely,

Henryk Minc

Encl.: Publication List

CC: Administrative Contracting Officer (1)
Director, Naval Research Laboratory (6)
Defense Technical Information Center (12)

HENRYK MINC

PUBLICATIONS

completed under ONR Research Contract N00014-85-K-0489

1 July 1986 - 30 June 1987

1. Permanental compounds and permanents of (0,1)-circulants, *Linear Algebra Appl* **86** (1987), 11-42.

2. Theory of permanents 1982-1985, *Linear and Multilinear Algebra* 21 (1987), 109-148.

3. On a conjecture of Brualdi, *Linear Algebra Appl.* (in print).

4. *Nonnegative Matrices*, Wiley, New York (in print).

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